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Sane Debate on Chemicals and Wildlife

WE MAKE NO apologies for writing again on the subject of agricultural chemicals and wildlife for, judging by a recent debate in the House of Lords (*Hansard* **230** (69) pp. 807-838, 25th April 1961) the constant hammering which the subject has received in the past year is beginning to bring forth beneficial results for all concerned, naturalists, farmers, chemical manufacturers and the general public alike.

Lord Shackleton opened the debate on Toxic Chemicals and Wild Life when he rose to ask "Her Majesty's Government whether they were aware of the catastrophic casualties caused to game and wild life by the use of agricultural chemicals. Do not be misled by this opening remark or others such as the "chemicalization of the countryside" which, if quoted out of context, would promote banner headlines and screaming letters of protest to the popular press; these and similar remarks made by Lord Shackleton, Lord Walston, making his maiden speech, Lord Stoneham, Viscount Goschen and Lord Douglas of Barloch—all of whom were concerned and worried by the indiscriminate use of toxic chemicals—were obviously seasoning added to the main course.

If any one phrase could convey the atmosphere of the debate it was Viscount Goschen's statement to the effect that *whereas in most discussions there are two sides to the argument in this case there are not and no one is fighting anyone else.* This was amply illustrated by the opening speaker Lord Shackleton, whose grasp and understanding of the many points of view involved was most impressive. Indeed in the opening passages of his account he stated that he was very concious of the extremely difficult and complex nature of the subject adding that there was nothing to be gained by scaremongering or attacking farmers, or manufacturers. "But," he continued, "the situation is a very dangerous one. I say this in the full knowledge that these chemicals have been of very great value to agriculture, not merely in this country but throughout the world, and that it is of profound importance that we should be able to have these aids to greater productivity. I believe that something like 80% are weed killers and are not dangerous, at least to animal life, in the majority of cases."

Lord Shackleton then went on to review some of the evidence which has implicated the recently introduced

(*Continued on page 207*)

BLACK-FLIES — PESTS OF MAN AND ANIMALS

Part II: Control by Insecticides

By R. W. CROSSKEY*, M.Sc.

CONTROL OF black-flies *Simuliidae* is directed against the larvae or against the adult flies since insecticides appear to have little effect on the eggs or pupae. There are four means of attack.

1. Application of larvicides from the ground.
2. Aerial application of larvicides.
3. Spraying from the ground against adult flies.
4. Aerial spraying or fogging against adult flies.

Each of these methods has been employed with varying degrees of success, but there is no doubt that the third approach is the weakest, and that in general fogging or spraying against adults from the ground has only a transitory effect. This method of control therefore has only a limited usefulness, but it can be used as a supplementary means of control to bring about temporary relief from biting in local areas where black-flies are a particularly intense biting pest. Experiments against adult flies using DDT aerosol fogs, BHC smoke bombs, pyrethrum bombs and so forth have been made in Alaska and New York State for human protection from bites, but no lasting or worthwhile control has resulted. Large truck-mounted fog generators are necessary to produce any effect on black-fly density and such machines are difficult to use away from roads; in general black-flies are a menace in rural areas where roads are scarce so that greater flexibility for adult fly control is obtained with aircraft. The control campaigns mentioned later in this article have achieved their success either through larviciding or by the *aerial* application of imagocides.

The selection of a particular method of application for a control project depends on a number of local conditions prevailing in the project area; as a rule black-fly problems in different territories are different in scope and nature. But in the planning of any control campaign the following considerations are among the most important:

1. Adequate knowledge of local black-fly biology, and pre-control surveys.
2. Nature of black-fly breeding sites.
3. Topography of project area.
4. Availability of large-scale maps.
5. Accessibility of breeding sites, presence of roads and trails.
6. Budgetary considerations—money available.

The relative importance of these factors varies from place to place. Thus the fourth consideration is of little importance in highly developed North America where such maps exist, but is frequently a source of difficulty in Africa where air-photo cover is often very incomplete. The second consideration is especially important since the type of breeding ground plays a large part in determining the appropriate control method. Black-flies which have a "linear" breeding distribution mainly confined to large rivers can be controlled from the ground, as relatively few application points are required to deal with a large area. On the other hand species which breed in multitudinous tiny streams are as a rule most easily controlled by an air-spraying technique, since in the case of these "area" breeding black-flies it is impossible to reach or even to find all of the streams from the ground. Thus, for example, the river breeders *Simulium arcticum* in Canada and *S. damnosum* in Nigeria are controlled by ground application of larvicides, whereas the stream breeders *Prosimulium hirtipes* and *S. venustum* in North America are controlled by aerial larviciding. Occasionally especial difficulties make it impossible to adopt the most desirable means of control (as in southern Mexico where the extremely mountainous terrain prevents the aerial control of *S. ochraceum* which breeds in the smallest trickles).

Aircraft spraying

This technique is widely used in North America but has as yet been only twice employed in *Simulium* control in Africa[36,38]. The insecticide is dispensed as an atomized spray, which, for application against larvae, consists of small droplets which will readily reach the streams; for use against adults the spray is more finely atomized. Experience has shown that

* *Commonwealth Institute of Entomology, London*

fixed-wing aircraft are more satisfactory than helicopters, especially light single-engine aircraft which can manoeuvre easily and be operated at low cost. Dispensing apparatus consists of boom-and-nozzle or rotary-bush assemblies, or straight pipes and emission is by pump-action or gravity feed; in the Adirondack Mountains where lake-based planes are used the insecticide is carried in, and dispensed from, the aircraft's floats. Aircraft spraying has the obvious advantages that a large area can be quickly covered, an unexpected outbreak of flies can be rapidly dealt with, and that both larvae and adults may be affected by the same application, but it also suffers from a number of drawbacks. The main ones are (a) that successful application is extremely dependent on good meteorological conditions; (b) that distribution of spray and dosage are hard to control accurately; (c) its comparatively high cost; (d) possible harmful effects on other organisms (more indiscriminate than with ground applications).

In extensive areas DDT spray is applied in parallel swaths by flying at right angles to the wind and at about 100 feet altitude so that the entire area is dosed with about 0.2-0.25lbs. of DDT per acre. The usual formulation is 10% DDT in fuel oil. For more isolated areas application can be made by flying along the courses of the streams emitting spray at intervals.

Ground application

Ground applications against black-flies are very widely used, and have certain advantages over aircraft applications, perhaps the most important of which is that the dosage of insecticide applied can be more easily calculated and controlled. The amount of insecticide required when dosing from the ground depends upon the discharge of water in the river or stream to be treated, and this is not always easy to calculate—it is a very much more difficult problem in many respects than the calculation of static volumes of water as in mosquito control. River flow is usually measured in cubic feet per second (cusecs) which is the product of width and mean depth in feet and current speed in feet per second. The flow of rivers is often extremely capricious and in Africa is markedly affected not only by seasonal fluctuations but also in the rains by local storms or by features of local relief—rivers may rise and fall considerably within a few hours so that there is a constant shift in the flow pattern, rendering the calculation of flow for control purposes very difficult. Furthermore rivers frequently present much irregularity in their courses, dividing round islands, losing themselves in broad swamps, dashing through narrow gorges, so that it is a problem where and how to make measurements. African rivers only rarely present more or less smooth and regular courses so that it is impossible to formulate rule-of-thumb means of calculation of flow, and the standardized figures of discharge which have been published[25] are of limited value. But rough measurements of flow must normally be taken to form some base-line for the estimation of the quantities of insecticide required. Current speed is probably best assessed with current-meters but float methods can give almost equally accurate results.

Larvicides are applied either in liquid form, running into the rivers from some type of dispensing apparatus supported over the water, or in cast blocks in which the insecticide is impregnated in a gradually-disintegrating block which is placed in the water and allowed to dissolve or break up. Blocks are normally made of plaster-of-Paris or some such material. Their usefulness is limited, and they are normally used only for very local destruction of black-fly larvae or as a supplement to other means of attack. To achieve a constant delivery rate of liquid larvicides during the dosing time a constant-delivery dispensing apparatus has been designed[19], but for practical purposes it does not as a rule greatly matter that delivery is rapid when dosing begins and gradually slows down, so that most ground larviciding is done with simple perforated containers or by running in from drums.

In ground larviciding dosing is normally at the rate of from 0.1-1.0 parts of insecticide (toxic isomer) to a million parts of water, most frequently between 0.2 and 0.5p.p.m., applied over 15 or 30 minutes at each application. This suffices to eliminate larvae for many miles below the treatment point. A large scale control campaign usually involves successive applications over several weeks at a number of treatment points on different rivers and streams.

Control of mass biting species.

Between 1947 and 1950 a number of experimental control projects against black-flies were undertaken in North America, and these clearly established that DDT was by far the most effective insecticide against the economically important mass biting species. DDT in fuel oil is now the standard insecticide used in Alaska, Canada and the United States. The principal control areas where annual aerial larviciding is carried out are at Baie Comeau on the north shore of the St. Lawrence river and in the Adirondack Mountains in New York State[20]. In both these areas *Prosimulium hirtipes* and *Simulium venustum* are the pest species. *P. hirtipes* overwinters as larvae and adult flies emerge in the spring soon after the thawing of the streams (about mid April), and *S. venustum* overwinters as eggs and so emerges later than *P. hirtipes* (usually about mid or late May); by mid July the main fly season is over and the rest of the summer is almost fly-free. In the Adirondacks there are usually two annual sprayings, one about late April to deal with *P. hirtipes* and another in late May or early June to control *S. venustum*, but

the later spraying is often less effective than the earlier one because of the development of foliage which partly prevents the insecticide from reaching the streams. The object of control in this area is to enhance the Adirondack tourist trade by freeing the area of the black-fly menace in spring and early summer, and each resort township undertakes control in its own environs—usually contracting with local free-lance pilots for a spray programme. Spraying is carried out both here and at Baie Comeau at an approximate dosage of 0.1-0.2 lbs. DDT per acre, but in Baie Comeau area there is only one annual spraying instead of two, the single spraying being carried out in about mid May so to control as far as possible both species in one operation. Control at Baie Comeau aims at the protection of personnel in the seasonal logging camps, and the annual spraying is done near the beginning of the pulp-wood cutting season.

Annual control of the mass livestock-biting species, *S. arcticum*, is also carried out in Canada. This species is mainly a serious pest in southern Saskatchewan, and experiments in its control were first undertaken in 1948 by the aerial spraying with DDT of the North and South Saskatchewan Rivers[2]. DDT in fuel oil at an estimated dosage of 0.13p.p.m. for 36 minutes applied to the South Saskatchewan eliminated larvae for a proven 17 miles below the treatment area and appeared to have a lethal effect as far as 90 miles downstream, but the application of 0.07p.p.m. to the North Saskatchewan was unsuccessful. In 1949 to 1951 larvicidings were made from the ground with single 15 minute applications of 0.1p.p.m. DDT which virtually eliminated black-fly larvae for distances up to 115 miles[17]. During this control it was found that DDT was adsorbed on to solid particles in the water which were ingested by *Simulium* larvae, and that treatments were most effective when the rivers were turbid, a fact which is now generally recognised in black-fly control. Recently there have been signs in Saskatchewan that annual control is now less effective than in earlier years, and larvicidings now apply a dosage of from 0.2-0.3p.p.m. for 15 minutes—a considerable increase on the 0.1p.p.m. used previously. This dosage rate continues to hold down the adult black-fly population to a negligible level, and there are now no deaths of livestock from *S. arcticum* bites as once frequently occurred in this part of Canada.

Control of onchocerciasis vectors.

Vector control in the Americas. No vector control is at present carried out in Guatemala or Venezuela and the only annual control programme against New World vectors is in Mexico, where a black-fly control campaign is being waged in the onchocerciasis zones in both Oaxaca and Chiapas States. A few years ago preliminary trials with DDT were made against the New World vectors (*S. ochraceum*, *S. metallicum* and *S. callidum*) in Guatemala, but these have not been followed up in that country although the lessons from this first use of DDT in Guatemala, were, as mentioned earlier, soon applied elsewhere.

In 1944-45 DDT as a xylene emulsion was applied to mountain streams in the neighbourhood of Yepocapa, within one of the Guatemalan onchocerciasis zones, and it was found that 0.1p.p.m. DDT eliminated larvae for a distance up to six miles from the treatment point[16]. Later, over a three-months' period from December 1952 to February 1953, a small-scale area larviciding programme was carried out in the same region of Guatemala, and 1,500 streams were treated at intervals over an area of 80 square miles[22], most of these streams were exceedingly small with flows under 100 gallons per minute (=0.27 cusecs) but a few were much larger streams flowing at more than 5,000 gallons per minute (approximately 13.5 cusecs). The small streams were dosed at 0.1p.p.m. DDT for 3 minutes, and the large streams at 2p.p.m. for 3 minutes or at 0.1p.p.m. for 60 minutes—the latter dosage giving effective control for a greater distance. Control by these means was only transitory, and streams were reinfested within 21 days.

Because of this rapid reinfestation the streams in Mexico are dosed every 20 days throughout the year. This year round control involves enormous effort under very difficult physical conditions for the streams are not only hard to reach but also difficult to find under the dense cover of leaves and herbage, and the chief vector (*S. ochraceum*) breeds in such tiny concealed trickles so that their location and treatment is essential for control. Furthermore the onchocerciasis zones lie in very mountainous country which is densely forested, so that aerial control in Mexico is precluded by the difficult terrain—and because the close forests canopy would prevent insecticide from reaching either the streams or the adult flies. (Control by helicopters might be feasible in these conditions but has not yet been attempted in the onchocerciasis areas; helicopters can be used in rugged terrain, require no runways, and their rotors tend to force the spray downwards through the tree-tops). Hence in the Mexican control areas all accessible streams are larvicided from the ground. Dieldrin has recently replaced DDT as the insecticide used, and dosing is at the rate of 0.25p.p.m. of dieldrin over 30 minutes;* this is calculated as 0.25 milligrams of dieldrin per litre of stream-flow. Treatment results in larval elimination for 600-800 metres below each application point, so that in the longer streams several application points are needed—normally at least two to every mile of stream. Reinfestation from untreated streams on the periphery of the control area (oı from

overlooked streams within the control area) is rapid, and so control is maintained continuously throughout the year; even so it has so far been impossible to prevent all black-fly biting within the control areas, and it is not yet certain that control is effectively reducing the onchocerciasis transmission rate. In Mexico therefore the vector control must be regarded as supplementary to control of the disease by excision of the nodules—in the onchocerciasis zones of Mexico some 70-80% of infected persons show palpable nodules, and the extraction of these nodules is a very valuable means of reducing the numbers of microfilarial worms available for transmission by the vectors. A nodule-extraction campaign was started in southern Mexico in 1939 and in the 19 years up to 1957 just over 389,000 nodules were removed; vector control was started to support this work in 1954-55. An account of the first five years of vector control has recently been published[33].

Vector Control in Africa. Control of the African vectors of onchocerciasis was first attempted with DDT as a larvicide in Kenya against *Simulium neavei* in 1946[18], and with DDT as an imagocide against *S. damnosum* on the Congo rapids at Leopoldville in 1948[38]. Since then control of *S. neavei* has been carried out in Uganda and in one area of the Congo, but very extensively in Kenya. In West Africa and in much of central equatorial Africa *S. damnosum* is the only vector of onchocerciasis (since *S. neavei* occurs only in East Africa and eastern Congo), and its control has been attempted in Nigeria, Ghana, Sierra Leone, Chad, Upper Volta, and to a minor extent elsewhere; in East Africa *S. damnosum* occurs as well as *S. neavei* and has been successfully controlled in Kenya and on the Victoria Nile in Uganda.

S. neavei control: The larvae and pupae of *S. neavei* occur on certain freshwater crabs, and the killing of the crabs was once envisaged as a control method for the black-fly. Insecticide trials against crabs soon showed that the crabs (*Potamonautes niloticus* in Kenya) can withstand large doses of DDT and other insecticides; furthermore killing of crabs fails because they are able to leave the rivers. Successful control of *S. neavei* depends on finding a dosage which will kill the black-fly larvae but which will not be toxic to the crabs, and it is essential to disturb the crab population as little as possible.

The association between the immature stages of *S. neavei* and the crabs was not discovered until early in 1950[24,35], although *S. neavei* had earlier (1946) been successfully eradicated from a small onchocerciasis area in Kodera district of Kenya by treatment of the rivers with DDT[18]. Various DDT formulations were used and applications were made from drip cans suspended over the rivers. The dosage varied from 1.3 to 34.6p.p.m. for 30 minutes, and treatments were carried out ten times at ten-day intervals, followed by applications every two weeks and then every month for a total period of five months. After this no adult *S. neavei* could be found, and no flies have been caught in the 65 square miles of the Kodera focus since, so that eradication has certainly been achieved.

Following the 1946 success in Kodera it was thought that the stage was set for complete elimination of *S. neavei* from the whole of Kenya, and as the next step a larviciding programme was put into operation in the much larger Kakamega-Kaimosi onchocerciasis area between November 1947 and April 1948 (after pre-control data on *adult* flies had been obtained). From 1.0 to 2.5p.p.m. of DDT was applied at 14-day intervals, but the outcome of the campaign was disappointing as after several months adult flies were again numerous and repeated larvicidings failed to eradicate *S. neavei* from the area. In 1950, after the discovery of the crab —*S. neavei* relationship, the reason for the failure in the Kakamega-Kaimosi scheme became clear—the streams in the forested areas where adult *S. neavei* were abundant did not harbour the early stages, which were attached to crabs in rivers outside the control area which had not been dosed. These rivers were in non-forested country away from the forest habitat of the adult flies. Thus control had been unsuccessful because of inadequate knowledge of vector biology, and this example of failure underlines very strongly the need for the fullest possible information on black-fly behaviour before control is attempted.

Rapid eradication

Once armed with a sound knowledge of the phoresy between crab and black-fly, the eradication of *S. neavei* in Kenya proceeded rapidly. The Kisii-Kericho onchocerciasis area, some 1,150 square miles in extent, was dealt with between October 1952 and January 1953; 55 rivers and streams were treated every 10 days for three months with 0.5 to 1.0p.p.m. DDT (a few very small streams were successfully dosed at only 0.1p.p.m.). In the succeeding five years no *S. neavei* could be found in the area and complete eradication appears to have been attained. In the Kakamega-Kaimosi onchocerciasis focus, an area of approximately 2,000 square miles, larviciding was begun in September 1954 and 184 watercourses were treated every 14 days for three months; 0.5p.p.m. DDT was applied to the larger rivers and 1.0 to 2.0 p.p.m. to streams. Some reinfestation occurred but re-larviciding in 1956 finally brought about full eradication.

Hence DDT as a larvicide applied from the ground has eradicated *S. neavei* from three onchocerciasis foci with a total area of about 3,215 square miles; in addition this vector has been eliminated from the small Riana focus by the bush-clearing experiment already

Larviciding against S. Damnosum on a river in Northern Nigeria. Photo 'Nigeria' Magazine.

referred to earlier. *S. neavei* is now apparently eradicated from Kenya[26], except perhaps where a focus on the slopes of mount Elgon in Uganda extends some way over the border into Kenya. The Elgon focus is isolated from the cleared foci in Kenya so that reinfestation is not likely to occur.

In the Elgon focus in Uganda[5] some trial use has been made of DDT adsorbed on to vermiculite in calico bags and with DDT-impregnated plaster blocks; the bags and blocks when placed in the streams flowing off Mt. Elgon slowly released the DDT and brought about some mortality of *S. neavei* larvae. To obviate possible danger to fish life only low concentrations were used, the initial concentration being about 0.05p.p.m. and the mean concentration over a 48-hour period about 0.01 p.p.m. However a number of circumstances have so far prevented a large scale follow-up in this onchocerciasis area.

Small-scale control of *S. neavei* has also been tried in the Bokuma onchocerciasis area in the eastern Congo. This is an area where almost impenetrable rain forest makes it extremely difficult to reach the rivers and streams, except by canoe, and where paths must be cut through the forests in many cases to allow transport of materials to the treatment points. The jungle conditions present a formidable obstacle to control and in this area eradication will prove extremely difficult if not impossible. Treatment of infested streams with 2.0p.p.m. DDT for 30 minutes every 10 days for a total of ten applications produced a significant reduction in the numbers of *S. neavei* adults but this was not maintained for very long; it served to show however that temporary relief from *S. neavei* biting (perhaps with some effect on the onchocerciasis transmission rate) can be obtained in the tropical rain forest where not all the infested watercourses can be dealt with at one time.

S. neavei in the Congo (and on Elgon in Uganda) undoubtedly presents a much more difficult problem than that which existed in Kenya and it is unlikely that eradication in these territories will automatically follow from adopting and adapting the techniques which will be successful in Kenya.

S. damnosum control: Larvae of *S. damnosum* live on trailing grasses and other objects in, as a rule, swift turbulent water, and control was first attempted in such a typical site on the Congo rapids at Leopoldville[38]. Until 1948 *S. damnosum* had been breeding in the extensive rapids where the Congo river narrows below Stanley Pool, and adult flies were responsible for very high incidences of onchocerciasis in African villages near the river and in the European town of Leopoldville itself. In an attempt to protect the population of Leopoldville and its environs from *S. damnosum* biting aerial applications were made to the Congo rapids of a toluene and gas oil solution of DDT; the main objective was to kill the adult flies by a residual effect on the marginal vegetation along the banks and on the grasses and bushes on the numerous islets studding the rapids, but some larval mortality undoubtedly occured as well. The insecticide was emitted from tanks in the wings and fuselage, and atomized in the aircraft's exhausts. Systematic coverage was given by flying at only about 35 to 50 feet at a speed of about 125 m.p.h., and applying a calculated 20 mgm. of DDT (para-para isomer) per square metre over 20 hectares per minute. Sprayings were completely effective and shortly afterwards no *S. damnosum* could be found in the area and no reinfestation has occured since; but the total eradication of the pest from the Congo rapids focus was possible only because of the high degree of isolation of the area from other foci.

DDT as a larvicide

In Uganda[5] a similar air spraying technique was envisaged for the eradication of *S. damnosum* from the Victoria Nile, but the more difficult terrain made flying hazardous and a larvicidal campaign was adopted instead. Preliminary air spray trials showed that accidental spraying on the water caused significant larval mortality, and the use of DDT as a larvicide appeared promising. Brreeding sites occured along a rocky 42 mile length of river from Lake Victoria to Lake Kyoga. The main difficulty was the larviciding of the 300 yard wide Ripon Falls near the outflow of the Victoria Nile from Lake Victoria, but this was overcome by applying the larvicide from a fire-pump mounted on a launch cruising near the outfall above the cataract. The fire-pump delivered a DDT emulsion concentrate mixed with lake water. In mid 1952 a total of 12 weekly

applications were made, each calculated to give a concentration of 0.4p.p.m. DDT over 30 minutes. Forty-eight hours after the first application no larvae could be found at any of the check-points over the 42 mile distance, and after the third application the adult fly density dropped from over a 100 flies per man-hour to nil flies. Some small-scale reinfestation later occurred, and in 1956 a total of 10 weekly applications of 1 part of DDT per 3 million parts of water were made to deal with this. These later applications were made by pouring the larvicide through the sluices of the Owen Falls dam, which had been constructed on the Victoria Nile soon after the first larvicidings had been carried out. The effect of the Owen Falls dam was to impound the water deeply over the Ripon Falls cataract, thereby eliminating possible *S. damnosum* breeding sites, so that the reinfestation after the 1952 larviciding was all downstream of the Owen Falls dam and the dam formed an excellent site from which to deal with the reinfestation. *S. damnosum* appears now to have been completely eradicated from the Victoria Nile area.

Control of *S. damnosum* by combined aerial spraying against adult flies and ground larviciding has been attempted with some success on the Kebbi River in Chad, but complete eradication from this isolated focus has not been attained[36,37]. The focus was believed to be isolated from other foci by a good 62 miles, and breeding of *S. damnosum* was confined to a 34 mile stretch of the Kebbi River above and below the Gauthiot Falls. Gamma-BHC was used for control, both as an imagocide and larvicide, although trials with this insecticide in North America had not given such satisfactory results as DDT. A gas-oil solution of BHC was applied by helicopter for a total width astride the river of about 325 yards and the estimated dosage was at the rate of 1 mgm. gamma-BHC per square metre at each treatment. Spraying was carried out in the late dry season (February-March 1955) when the adult fly population is usually minimal and the breeding sites very restricted; ten consecutive treatments of the 34 mile stretch were originally planned, but the upper two-thirds of the project area in fact received twelve dosings and the downstream third received six dosings. The larvicidings were carried out at the same time as the adult sprayings, and six 30 minute treatments were made at each of three treatment points. After the first larvicidings and air spraying no larvae or adult flies could be found, and at the end of the insecticiding period it appeared that eradication had been achieved; however with the coming of the rains rapid reinfestation occurred and by late July 1955 adult *S. damnosum* were again plentiful in the Kebbi River focus. It was thought unlikely that, with the high degree of isolation, reinfestation could have taken place from another focus and the fly appeared to have survived (how is uncertain) within the control area. A further attempt at eradication was made in the following dry season by larviciding only; nine weekly applications (instead of six) of gamma-BHC were made, and the number of treatment points was increased from three to five (one point for about every seven miles of breeding ground), but despite these efforts and the isolation of fly focus complete elimination has failed, defeating the hopes of swift eradication by helicopter and ground onslaught.

Practicability of annual control

In much of West Africa onchocerciasis and its vector occurs in enormous diffuse areas instead of in more or less closely circumscribed foci, making eradication a vastly more difficult problem than in the isolated areas—such as those successfully dealt with on the Congo and Victoria Nile. In these extensive non-isolated areas it is impossible to deal with all the breeding places at one time so that cleared rivers may be swiftly recolonised from uncontrolled ones. To assess the practicability of annual control in such areas a larviciding project was instituted at Abuja in Northern Nigeria in 1956[14]. This soon showed very encouraging results. Routine annual control continues at Abuja, and control by the methods worked out there is being extended to other parts of Nigeria. The Abuja control area covers about 1,200 square miles, and about 32,000 persons are protected from *S. damnosum* biting and thereby from contracting further onchocercias infection. In the first two years DDT larviciding was carried out in the late dry season and early rains (February-May), using a diesel oil formulation, but later DDT emulsion was used and larviciding took place in the early and mid rains (mid May to August). In the first year the mean dosage was 1.4p.p.m. DDT over 30 minutes and 1 p.p.m. over 30 minutes in the second year; in the third year (1958) when DDT emulsion was first used the dosage was 0.5p.p.m. for 30 minutes, since 1p.p.m. proved very toxic to fish and presented some difficulty because of the large quantities of emulsion required at each treatment when the river was flowing high (the quantity of insecticide used being determined by river flow). The success of the Abuja control project was gauged by the adult fly density as determined by the number of flies caught per man-hour; before control in 1955 *S. damnosum* occurred throughout the Abuja control area in very high numbers, but after the first year's larviciding the adult density was reduced by 96%. After the second year's larviciding results were good but less striking and adult fly density was reduced by 82% as compared with the pre-control year; in the 1957 larvicidings the rivers had been extremely low and had often failed to carry down the DDT sufficiently to affect all the breeding sites. In the third and succeed-

ing years larviciding was done later in the year when good river flow ensured a better carry-down of the DDT. Three rivers in the Abuja area were initally dosed to deal with a total distance of about 110 miles of breeding ground; in the first year four treatment points were used but it was later necessary to increase the number to seven, and to dose in addition a small fourth river in which some minor infestation was discovered. Larval surveys showed that treatments eliminated breeding for 15 to 23 miles below a treatment point and for considerably greater distances when the rivers were in spate. Thus the Abuja work has clearly shown that even in very large diffuse onchocerciasis areas the control of *S. damnosum* is possible by using DDT as a larvicide, and has demonstrated the feasibility of combatting onchocerciasis in such areas by vector control; but control pressure must be maintained since reinfestation is rapid in non-isolated areas once control ceases.

In other parts of West Africa *S. damnosum* is at present being actively controlled in Ghana, Upper Volta, Dahomey and Sierra Leone but the full results of such work are not yet available. Certain advantages obtained by adsorbing DDT on to suspensions of clay particles when larviciding against *S. damnosum* have however been demonstrated in Ghana[27].

Costs of control

Numerous factors determine the cost of control and no generalised figures can be given. Costs will depend on the control methods which have to be adopted to suit local black-fly biology and local topography, on the extent of the control area, on whether complete eradication is aimed at or whether routine annual control will suffice, on local costs of insecticides, labour and transport and so on. A few examples of costs however are as follows:-

Control of mass biting species in North America costs approximately $1000 for a single aerial spraying of DDT over 100 square miles (which involves some 400 flight miles taking several hours). Two such sprayings are normally required so that a township desiring control over an area about ten by ten miles may spend $2000 annually for protection from biting. For a 100 square miles area in Guatemala it has been estimated[15] a larval control programme against onchocerciasis vectors would cost about $800 per month or nearly $10,000 annually. At the present time in Mexico the annual cost of vector control is about 160,000 pesos (£4,700) in both Oaxaca and southern Chiapas. The Mexican total annual expenditure of nearing £10,000 is comprised of 75% salaries and wages, and only 12½% on insecticide—the balance being made up of transport costs, etc. At present by no means all the onchocerciasis area is being dealt with.

The generally easier conditions in Africa make the control of African vectors rather less expensive. Eradication of *S. neavei* in Kenya was estimated to have cost between 13/- and £1-4-0 per square mile for the larviciding campaigns, and about 7/- per square mile for preliminary survey[26]. The Abuja control project in Nigeria against *S. damnosum*[14] cost a little over £1000p.a. for the first two years, excluding salaries of permanent staff; for this outlay about 32,000 people were protected from biting (and thus from contracting fresh onchocerciasis infection) over an area of some 1,200 square miles, an approximate cost of 16/- per square mile.

* In the published account of this control work (Ruiz Reyes 1959, p.50,52) the dosage has unfortunately been cited in error as 0·00025 p.p.m But, as given elsewhere in the paper, the dosage applied is in fact 0·00025 grams per litre of water, which is 0·25 p.p.m (since 0·00025 grams per litre is 1 gram per 4,000 litres or 4,000,000 ccs, i.e. a quarter gram in a million grams or 0·25 p.p.m). The error gives a false impression that dieldrin is more effective at lower dosages than DDT.

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Sane debate on chemicals and wildlife *(Cont. from p.199)*

dual purpose seed dressings in the deaths of wildlife and it was notable that he did not make a general attack on the use of chemicals but confined his comments to those seed dressings containing high doses of dieldrin, aldrin or heptachlor against which there is a large amount of evidence. Even with these particularly dangerous products his lordship did not demand that they should be condemned or outlawed out of hand but offered the sound suggestion that they should only be used, say on the recommendation of a N.A.A.S. Officer, when there was an undoubted high infestation of wireworm or wheat bulb fly and not used indiscriminately, as may occur at present. If some of these chemicals were even then found to be exceptionally dangerous to wildlife they should be withdrawn either voluntarily, as was the case with arsenites, or they should be prohibited by law.

Lord Shackleton concluded his speech by making a plea to the Government that, whatever short term steps they take, the Government should also give more support to ecological research particularly in relation to the long term effects of the use of agricultural chemicals.

Lord Walston making an eloquent maiden speech followed the same considered and constructive approach as Lord Shackleton, again making a plea for further positive research by the Government on the long term effects on wildlife of the use of chemicals in agriculture.

Replying for the government Earl Waldegrave, Joint Parliamentary Secretary, Ministry of Agriculture Fisheries and Food emphasised that the Government were not complacent, were fully aware of the problem and were taking action.

However, the purpose of this account is not to review the various opinions that were put forth or to quote the facts that were given, for they can, and should, be obtained from *Hansard.* We have mentioned the debate in order to draw the reader's attention to the fact that there are now people who, although deeply concerned with the effects of chemicals on wild life, are willing to discuss the subject, knowledgeably and sensibly; people who understand the necessity of using chemicals in agriculture; people who realise that the so called "balance of nature" was disturbed long before agricultural chemicals came on the scene; people who realise the dangers of generalisation and illogical mudslinging which in the past has so irritated manufacturers and users that their appreciation of the real dangers of the use of chemicals has been sometimes dulled. Now with the assistance of such people as Lord Shackleton, Lord Walston and others we can hope to reap greater benefits from the use of pesticides whilst reducing the hazards to wild life. We hope that other naturalists and conservationists will adopt their moderate and constructive approach.

CONTROL OF QUELEA BIRDS WITH PARATHION

By I. R. JAMES

In Southern Africa, where the adult quelea bird daily consumes its own weight of small grains, parathion is being used as a remedy with promising effect.

OF THE MANY new insecticides developed in recent years, some have proved outstanding in their effectiveness against a large range of insect pests, and to a certain extent in their selectivity, whereby parasitical and predatory species are not killed. Of these, parathion, an organo-phosphorus insecticide, is a good example, but unfortunately possesses a high degree of mammalian toxicity, which is a limiting factor in its widespread use in agriculture.

However, in Southern Africa, the inherent mammalian toxicity of parathion has been put to good use in the control of the red-billed finch, *Quelea quelea*, which has assumed a position of considerable importance as an agricultural pest, it being estimated that each adult bird consumes its own weight of small grains a day. As the red-billed finch roosts and breeds in colonies containing some millions of individuals, it can be appreciated that a large loss occurs to the surrounding farmers, due to the presence of these unwelcome neighbours. The Quelea problem has in fact assumed such proportions that a symposium on it was held in Northern Rhodesia in 1957 and was attended by delegates from the Federation of Rhodesia & Nyasaland, France Portugal, Sudan, Union of South Africa, Bechuanaland, Tanganyika, Nigeria, Kenya and the U.S.A. A summary of the proceedings was published by Colwill.*

In the Union of South Africa and Rhodesia, *Quelea quelea* is normally found roosting near cultivation, and great success in control has been achieved by the use of aircraft in spraying the colonies at night from the air, using parathion, but in April, 1957, the red-billed finch was discovered breeding in Portuguese East Africa. Extensive areas of breeding were localised some 90 to 120 kilometers from the border of the Kruger National Park. It was thought that large scale operations against the birds in South Africa had caused them to forsake their normal areas. As the damage being suffered by neighbouring farmers was assuming alarming proportions the Portuguese Department of Agriculture commenced operations against the birds. Initial efforts to destroy the colonies by bulldozing the trees and shrubs containing nests and young into large heaps and burning them, and burning individual trees with flame-throwers, were unavailing in reducing the damage being suffered. The Department therefore called on a local firm of pest-control contractors for assistance, and the services of an experienced pilot and properly equipped aircraft were secured at short notice, and a plan put into operation, to destroy as many of the birds as possible, by spraying them from the air with parathion at night.

Farming properties widely dispersed

The area in Portuguese East Africa where the finches were discovered breeding, although containing farming properties, consisted in the main of virgin thorn-bush scrub, interspersed with cultivated lands and cattle grazing ground. The properties in the area were widely dispersed and it was possible to travel for a day between one property and another without seeing signs of human occupation or cultivation.

The main breeding areas were localised on two more or less adjacent properties, and were first surveyed from

* *Lately Entomologist, Ministry of Health, Northern Nigeria.*

the ground. The pilot was able to help in this survey as, from the air, the droppings beneath trees showed up clearly as white rings. By means of this survey the actual areas to be sprayed were determined. In cases where this finch is only roosting, an endeavour is made to concentrate the birds into as small an area as possible, by beating, in order to cut down the cost of the treatment, which is high. Subsequent events proved that beating is of doubtful value where breeding areas are concerned, as, if there are young birds at nest, the adults tend to settle on the nests again after the beaters have passed.

In any case, when breeding, the colonies are more concentrated than in the case of roosting flocks. In Portuguese East Africa the red-billed finch appears to nest exclusively on thorn trees, and occupies its area to the exclusion of other species of birds.

Sequence of events

Once the limits of the areas requiring treatment were fixed, they were marked out with flags on poles, in daylight in order to enable the pilot to examine them closely from the air and note any particularly high trees or other hazards. The actual sequence of events was: determination of the area, marking this out with flags, beating—beginning one hour before sunset—substititution of the flags by hurricane lamps, withdrawal of the beaters, and spraying with parathion one hour after sunset.

The pilot assisted in beating by flying low in concentric circles around the area and after an attempt was made to beat the birds into the localised patches of scrub, the flags were taken down and lighted hurricane lamps put up in their place. These were the ordinary paraffin lamps and not pressurised "Petromax" lamps. The work proceeded smoothly but not without attendant dangers, as a large green mamba was shot out of a bush a few feet from a beater's head.

Also the fearsome thorns with which the trees and bushes were armed, some two inches in length, proved a real hazard to the natives trying to tie poles into the trees.

Due to the extremely dangerous nature of parathion extensive safety precautions had to be observed, and farmers and surrounding native villages were warned. It is interesting to note that in this region the drum is still used as a means of communication, and was utilised on this occasion to warn more distant villages, very successfully and efficiently as we later discovered. Civil authorities warned farmers of the dangers of grazing cattle in the sprayed area for a period after treatment, and these areas were sign-boarded by Department of Agriculture officials.

On the actual day of treatment, arrangements had to be made to ensure that the ground-controller was satisfied that all beaters and other persons had left the area, and a rendevous agreed with the pilot. This was the key-position from which the pilot received light signals from the ground-controller concerning whether he could go ahead with the operation. The controller discovered that a knowledge of the Morse code could be a useful part of a pest-control operator's training.

Communications in the area were very difficult. The rendevous point had to be sited at a safe distance from the areas to be sprayed, and could itself only be reached after a three-quarter of an hour's drive over a barely discernable bush track.

Moonless nights are chosen for this type of operation as the pilot is better able to pick up the weak yellow light of the hurricane lamps, and it is noteworthy that the pilot is guided solely by these lamps, and that the spraying is carried out at tree-top height. If the landing lights are switched on over the area, the birds will rise up in clouds in front of the aircraft, causing a serious accident. It is one of the most dangerous of air-spraying operations, demanding a high degree of skill on the part of the pilot, who was in this case very experienced in this type of treatment, and a veteran pilot of World War II and Korea, having graduated from jet fighters to crop-spraying aircraft.

The operation was carried out successfully. As a matter of comparison, about 60 acres of actual ground area was sprayed, and an estimated 25 million finches killed. At sunrise the following day about 5 per cent of the birds were still alive but succumbed in the space of a few hours, and it is thought that not a single bird survived the treatment.

Death roll of beneficial birds small

A point of considerable interest is that very few beneficial birds were killed. In all, five Maribou storks, which are scavengers of importance, and protected birds in Portuguese East Africa, died through eating the bodies of poisoned finches, two large hawks died similarly in another area and a lizard-buzzard was found suffering from the effects of parathion, but recovered in captivity.

The red-billed finch is eaten by local natives, and the day following the treatment was consequently the most dangerous. After this, the dead birds decomposed rapidly.

Parathion was used as technical grade at the rate of a quarter of a gallon per acre, made into solution with diesel oil and butyl alcohol, the dilution rate depending on the discharge rate of the aircraft. Personnel mixing the insecticide and filling the aircraft used full protective clothing and full face masks. An oil solution was preferred, as a water-miscible emulsion mixture would tend to be repelled by the birds' feathers.

By prompt action and the timely and expert application of a material which is primarily an insecticide, a major threat to agriculture in the area concerned was removed in the space of a few days.

LABORATORY TECHNIQUE FOR TESTING WOOD PRESERVATIVES

By Jean M. Taylor,* B.Sc., M.I.Biol.

AN ACCOUNT is given of a method employed at the Forest Products Research Laboratory of assessing the effectiveness of wood preservatives in preventing attack by *Lyctus brunneus* Steph. European oak (*Quercus robur*) sapwood blocks, ($4 \times 1\frac{1}{2} \times \frac{1}{2}$in. and $1 \times \frac{1}{2} \times \frac{1}{2}$in.) are dipped for 1 minute in the preservative, ventilated, and exposed to *Lyctus* beetles at conditions of 25°C and 75 per cent r.h. Records are kept of the condition of the beetles. The smaller samples are examined for egg-laying and hatching and the larger ones used for completion of larval development and emergence of adults. Results are obtained in 3 to 4 months.

Introduction

The life-cycles of some of the commoner wood-boring beetles in Great Britain occupy a number of years under normal conditions: most of the life-cycle is spent in the larval stage within infested wood and beetles emerge during very limited periods. Evaluation of wood-preservatives must be confined to this emergence season if egg-laying is to be included, but where such data are not needed tests may be carried out throughout the year by the transfer of partly grown larvae. In either case, however, tests involving the whole life-cycle or completion of development under normal conditions are too protracted for general use.

Amongst the wood-boring insects in this country, the powder-post peetle *L. brunneus* readily responds to culturing procedure and under controlled conditions of 25°C and 75 per cent r.h., the life cycle (normally 1 or 2 years) is reduced to 3 to 4 months and beetles can be obtained at any time of the year (Harris and Taylor, 1960). The following procedure has been adopted at this Laboratory for the evaluation of wood preservatives where *L. brunneus* is suitable for use as the test insect.

Test method

Wood samples

Branch wood is collected from newly felled European oak (*Quercus robur* L.) in autumn and early winter, when it is likely to contain sufficient starch for *Lyctus* attack (grades 4-6) (Phillips, 1938). Straight lengths of 13in. or more and over 5in. diameter are suitable. The sapwood is removed in four slabs, and strips $1\frac{3}{4} \times \frac{3}{4}$in. in cross-section are cut from each slab with the wider dimension in the tangential plane. These strips are open-piled and dried in the laboratory over a radiator (ventilation being increased with an electric fan) to approximately 15 per cent moisture content based on the oven-dry weight of the wood (about 2 weeks). Some of this material is then sawn to $\frac{3}{4} \times \frac{3}{4}$in. sections to provide small samples, and all strips are planed to final dimensions ($1\frac{1}{2} \times \frac{1}{2}$ or $\frac{1}{2} \times \frac{1}{2}$in.) before cross-cutting into blocks of the following sizes large— $4 \times 1\frac{1}{2} \times \frac{1}{2}$in. and small— $1 \times \frac{1}{2} \times \frac{1}{2}$in.

Samples free from knots and heartwood and with adequate starch content (grades 4 to 6) are selected. Exposed vessels in tangential and radial faces are examined for the presence of tyloses; blocks with excessive numbers are discarded since they might prevent egg-laying (Bletchly, 1959).

Treatment

Twelve samples of each size are allocated for treatment

* *Forest Products Research Laboratory*

Left: *Fig. 1 (a) large sample in jar (x. 1.)*

Below: *Fig. 1 (b) small samples in tin (x. 1.) (Cambric cover removed.)*

with each concentration of preservative and twelve for untreated controls. The blocks are stored at the test conditions of 25°C and 75 per cent r.h. for 7 days to obtain an equilibrium moisture content. The end grain of all blocks is then sealed with paraffin wax or other suitable material to prevent excessive penetration of the preservative. The samples are weighed, dipped for 1 minute in the preservative, excess liquid blotted off, and immediately re-weighed. Following treatment the blocks are ventilated in a forced draught at 30°C for 1 to 2 days until the solvent has evaporated.

From the 12 large samples per concentration, 3 having an equal retention of solution are selected for initial exposure. These samples are placed individually in glass jars with a circle of paper in the bottom as a foothold for the beetles (Fig. 1a.) and a further 3 untreated samples are exposed in the same way. The small samples are similarly selected and the same numbers of treated and untreated blocks are used; however, in this case 3 samples treated at the same concentration are placed together on stickers (softwood or metal) in a small tin (3in. diameter × 1in. approximately) which is also provided with a paper foothold (Fig. 1b). All samples are then stored under the test conditions for one week.

The remaining samples may subsequently be exposed to attack at intervals to determine the permanence of the preservative.

Exposure to beetles

Beetles are obtained from cultures, sexed (Fig.2) and 4 pairs added to each jar and 5 pairs to each tin. The higher proportion of beetles to volume of wood in the small samples is used since these blocks are to be cut up after eggs have hatched and before much boring and consequent competition for food material has begun. Where large blocks are left for completion of the life-cycle fewer beetles to volume of wood are required. The jars and tins are covered with two thicknessess of cambric (a finely woven cotton) held in place with rubber bands and stored under the test conditions.

Precautions against infestation by the mite *Pediculoides ventricosus* Newport are necessary and differ only from those described by Harris and Taylor (1960) in that cambric covers on tins and jars are used instead of filter paper tops throughout the test.

Assessment of results

Under the test conditions *L. brunneus* adults normally live about 30 days. Insecticides with contact and/or fumigant action may reduce this period or affect the beetles, as judged by abnormal movement. Such a condition may persist for some days prior to death but during this time egg-laying may be greatly reduced if not completely prevented. The speed of action of the material under test is assessed by the time interval before the adults are 'affected', by recording daily the condition of the beetles.

One week after the beetles are dead, by which time hatching should have been completed, the small blocks are cut up with a hand razor under a binocular microscope. Since the end grain is sealed, any eggs laid will be in the vessels opening on the sides of the block or beneath tasting marks. Many preservatives which protect timber from damage by *L. brunneus* do not prevent egg-laying, but kill the young larvae on hatching, before tunnelling and consequent damage can take place. The total number of eggs per concentration and percentage of surviving larvae are compared with those in untreated control blocks.

The large samples are stored until emergence of the first generation of adults from untreated controls is in progress (3 to 4 months). If no exit holes are present in the treated samples they are split with an axe to ascertain whether larvae or tunnels are present, since develop-

Continued on p. 215

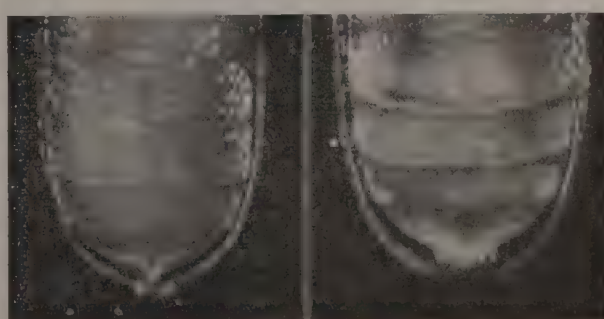

Fig. 2. Secondary sex characters Lyctus Brunneus Steph. *Setae on last visible abdominal converge to a point in female; form a fringe in male.*

Above : Coelopa frigida *on seaweed at adult and larvae stages.*
Below: *Close-up of an adult* Coelopa frigida. *Shell photographs.*

COELOPA FRIGIDA– a fly pest of the seashore

By H. J. EGGLISHAW*, B.S.C., Ph.D.

ON MANY occasions during the past ten years or so seaside authorities have complained of the annoyance to holiday makers on the beaches caused by the activities of plague-like numbers of a black bristly fly. The fly is *Coelopa frigida* (Fabricus), one of a small but distinct family, the Coelopidae, which inhabit shores the world over.

All five species of the family that occur in Britain frequent and breed in decomposing heaps of wrack that have been cast up beyond the high tide line on the beach. For this reason they have become known as seaweed flies, and because *C. frigida* is the most common of the species it is often referred to as *the* seaweed fly. Normally the flies spend their time beneath the wrack and shingle and pass unnoticed, but there are occasions when they occur in vast numbers and become more active. Then their occupation of the shore and their habit of alighting on sunbathers and holidaymakers make the fly a pest. But they are in no way harmful or destructive; they are pests only because they are a nuisance.

That there have been more complaints in the past few years than previously has probably as much to do with changes in human behaviour and attitude as it has with the increase in number and distribution with which *C. frigida* has been accredited. As in other fields of human activity, people are continually becoming less tolerant of discomfort and more aware that if their complaints

* *Fresh water Fisheries Laboratory, Pitlochry, Scotland*

are given publicity something will be done about them. It is more than likely, too, that due to their own increase in numbers in the past few years, holidaymakers are being forced to use beaches that are less attractive. The seaweed fly is more closely associated with wrack and shingle, in which it can hide, than with the sand in which it can find no safe place. People normally avoid shingle beaches in preference to sand, but due to the larger number of people spending their holidays at the seaside, they are being driven to shingle beaches and into the proximity of wrack beds.

Besides being an annoyance on the beach during the day, the seaweed fly has been attracted in large numbers to the lights of cafes and places of amusement on the promenade at night.

Life-history

The adults are bristly, flattened, black flies of very variable size, males measuring from 3mm. to 9mm. long and females from 3mm. to 7mm. The larger flies are much more bristly than the smaller ones and look quite different from them.

Each female lays one or two, and sometimes three, batches of 60 to 80 eggs on the surface of *Fucus* or *Laminaria* where beds of this wrack are formed. When the young first instar larvae hatch they burrow into the seeweed and feed with only their posterior spiracles remaining in contact with the air. The second and third instar larvae sometimes feed in this position, but if the wrack is soft they feed on the outside surface.

The larvae are never found in the drier surface layer of wrack that covers a heap of the weed put are always a few inches below the surface in the wetter, more decomposed and sometimes pulp-like wrack. The larvae, which superficially resemble maggots of the house fly, are well adapted to living in wrack in this state. Their mouth hooks are bifurcate, each being composed of two downwardly-curved finger-like processes with rounded edges, and the sclerotised teeth on the head lobes are broad flattened plates which clearly project from the lobe surface. In feeding, the head of the larvae is raised from the wrack surface and extended forwards, it is then lowered on to the wrack surface and retracted, the mouth hooks pulling back the soft wrack. When the larva is suspended in soft wrack material by the hairs on the posterior spiracles, the head is constantly being extended and retracted, food caught under the mouth hooks and behind the sclerotised teeth being pulled back into the mouth. Since the larvae have to move through or over soft materials they require large gripping surfaces and these are provided by numerous black sclerotised spines in transverse rows on the ventral surface. The spines vary in size but those in the same row are usually alike.

The larvae are supplied with four groups of broad hairs arranged at right angles to each other on their posterior respiratory spiracles, which are splayed over the surface of the wrack. These groups of hairs have three functions. Firstly, the splayed hairs act normally as a check against the larvae moving too deeply into the soft wrack and losing contact with the air. Secondly, when the larvae enter soft wrack the hairs are forced backwards to form a cone over the respiratory spiracles so preventing them from becoming blocked. Thirdly, this bending backwards of the hairs causes air to be entrapped within the cone formed and allows the larvae to remain entirely immersed in the wrack for a short time.

The larvae pupate in the drier parts of wrack beds or in nearby shingle often forming large masses of several hundred adhering puparia.

The whole period from the egg-laying to emergence of the adult takes about fourteen days, but this period can vary greatly depending on the temperature and the availability of food.

Because of the breakdown of complex organic compounds in the wrack, the temperature of the wrack beds is always a few degrees higher than that of the surrounding air and this extra warmth allows *C. frigida* to breed almost continually throughout the year.

A full account of the biology of this fly, together with that of three other members of the Coelopidae, has recently been published by the writer (*Trans. R. Ent. Soc. Lond.* Vol. 112. p.109-140).

The large populations

Larvae of *C. frigida* occur nearly always in large masses of wrack and very rarely in small heaps. The larvae either occur in large numbers or are absent altogether. Much larvae activity seems to be necessary to hasten the decomposition of the wrack to make it suitable for feeding purposes, and when only a few larvae are present they do not *survive at all well.*

With batches of eggs hatching together a wrack bank soon becomes a mass of feeding and crawling maggots. At times over 600 third instar larvae occur per 1000cc. of wrack material and a wrack bank can contain several million larvae. Such vast numbers occur also in *Fucomyia allauadi* Seguy, a closely related species inhabiting Madagascar. B. R. Stuckenberg of the Natal Museum estimated that there were approximately 63 million pupae on a 203 yds. long stretch of beach on the island. The pupae were being washed out of the sand and deposited in rows between the tide marks (personal communication).

Very few of the larvae or pupae of *C. frigida* become parasitised, nor are there many predators in the wrack beds.

So within about two weeks of a mass of seaweed being cast up onto the shore millions of adult flies can be produced from it. The fortnightly life-cycle has presum-

ably evolved in response to the rhythm of highest tides —the spring tide—which also occur at approximately fortnightly intervals.

The one danger with which the young stages have to contend is the destruction of the wrack bed by stormy seas or an unusually high tide. The larvae are then washed out of the wrack to be drowned or eaten by birds. The population then suffers very heavy losses and may even be annihilated.

It is, of course, because of this hazard and the usual short life-time of wrack beds that *C. frigida* has such a high rate of multiplication. It is when a lot of wrack material remains undisturbed that plague-like numbers of the flies are produced.

Control of the fly

The most efficient and simplest way of avoiding a plague of seaweed flies is to destroy the young stages and breeding grounds and so prevent its formation, as often occurs naturally. This destruction can be brought about by either removing the wrack beds from the beach and treating them as refuse or by carrying them some distance below the high tide line so that the larvae are either eaten by birds or drowned after being washed from the wrack by the incoming tide.

There should be no difficulty in effecting this control since the wrack beds are obvious and lie within clearly defined limits, and it is known that the young stages do not occur anywhere else. Removing the beds from the beach has the additional advantages that with them goes the smell of decomposing wrack which many people find unpleasant, and the wrack is no longer available for future generations of the fly.

Due to various structural features of the shore, wrack beds tend to be formed at the same places over and over again and some areas are thus more prone to become plagued by flies than others. The wrack beds in these areas could be inspected regularly, say once every two weeks, and when large numbers of larvae are found, the beds should be destroyed.

Up to the present *C. frigida* has borne all the blame for the plague of flies, but the closely-related *C. pilipes* is probably at times as much to blame. Usually both species occur together. What has been said above about the life-history and control of *C. frigida* applies also to *C. pilipes*. The other three species of the family that occur in Britain are found in smaller amounts of wrack and are never as numerous as the *Coelopa sp*. There is little chance of their populations ever reaching pest proportions.

Laboratory Technique for Testing Wood Preservatives *Cont. from p. 211*

ment may be retarded under adverse conditions. The efficacy of the preservative is assessed by the final condition of the large samples as compared with untreated controls.

In laboratory tests it is essential that the preservative completely prevents establishment of infestation, particularly in the case of surface treatment. In practice larvae which survive long enough to reach the untreated part of the wood could cause severe damage. The toxic limits of the material under test are given as lying between the lowest concentration at which no larvae survive and the highest concentration at which damage occurs. Additional information may be obtained on the mode of action of the preservative from its effect on the original adults and on young larvae (if any) in the egg-laying blocks.

This test method described above is designed solely for use when *Lyctus brunneus* is the test insect. Susceptibility to preservatives varies with different insect species, and toxic values obtained for one insect are therefore not necessarily applicable to another. Preservative problems also vary with the habits of the insect concerned, for example, protection against *Lyctus* is required for relatively short periods mainly during seasoning and storage prior to manufacture. Risk of attack is greatest during this time, since surface finishes applied to furniture and joinery give some protection against egg-laying; further the risk of introduction of a source of infestation is slight away from manufacturers' premises. With the common furniture beetle *Anobium punctatum* Deg.), risk of attack continues for many years after the wood is put into service, and the rough surfaces of structural timbers in particular provide suitable egg-laying sites for these insects. Preservatives with long lasting protective qualities are therefore desirable. Tests with *L. brunneus*, however, may be useful when a material of unknown toxic qualities is to be investigated. Toxic values obtained from preliminary tests with this species may be used as starting points for long-term tests with other wood-boring insects.

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NEWS AND NOTES

Combined Assault on Bilharzia

A combined assault on bilharzia, one of the most debilitating tropical diseases remaining in Southern Africa was agreed on by scientists from the Union, Mozambique, Swaziland and Bechuanaland who attended talks on the subject at the C.S.I.R. in Sept.

The conference was a follow-up to discussions held in Lourenco Marques last year, when it was decided that collaboration between the various territories in Southern Africa was essential if bilharzia were to be curbed and better understood.

At the meeting in Pretoria a resolution was adopted to extend the scope of the work presently in progress. A programme was drawn up, which included the interchange of research workers, the establishment of training courses for people concerned with bilharzia control, and the establishment of distribution centres for literature and information on bilharzia.

It is hoped that complementary research will throw light on questions like the pathology of bilharzia in the Union and Mozambique. The disease is usually severe in Porguguese East Africa, claiming a heavy toll of lives, whereas its effects appear to be less pronounced in the Union, even in areas like the Eastern Transvaal where virtually the whole Bantu population is infected.

Delegates to the conference agreed that a concerted effort would be required to eradicate bilharzia in existing endemic areas and to prevent it from spreading via water control and irrigation schemes. The snail host shows scant respect for national boundries and effective control must rely on a combined approach.

Portuguese representatives included Prof. Fraga de Azavedo, Director of the Institute for Tropical Medicine Lisbon, and Drs. Damaso Prates and Tito de Morais, of Mozambique. Dr. B. Wilkin represented Bechuanaland, and Dr. R. Gauldie was the for Swaziland. The South African team was led by Dr. J. H. S. Gear, Chairman of the C.S.I.R.'s Bilharzia Steering Committee.

Visits were paid to the Bilharzia Research Unit at Nelspruit; the Water Research Institute of the C.S.I.R.; the Veterinary Research laboratories at Onderstepoort; the S.A. Institute for Medical Research in Johannesburg; and the Department of Zoology at Potchefstroom University, to give delegates an idea of the work on bilharzia sponsored by the C.S.I.R.

Fumigation of Dried Mushrooms

The conventional method of preservation in cold storage is only partly efficient in the case of dried mushrooms. For one thing, the temperature is not low enough to kill pupae eggs and chrysalides. Neither can these be disposed of by heating, which would alter the mushrooms. Highly toxic gases are, similarly, inapplicable for obvious reasons.

Recent investigations have shown that effective pest elimination, at all stages from egg to full-grown maggot, can be achieved, without altering the mushroom, by treating it with methyl bromide in special artificial atmosphere.

The treatment is usually carried out in waterproof enclosures. The gas is injected through pipes and is circulated by forced draught delivered by two fans. A special electrical heating system prevents bromide condensation in cold weather. The gas remains in the enclosure for 15 min. and is then vented out through a flue.

Three samples of maggot-infested mushrooms were treated with methyl bromide, the quantities being raised from 30-40-50 g./cu.m., and the results found by entomological examination after 48 hr. are given in the table, page 25. (A control sample of an infested but untreated mushroom was also examined.) 20 days later a further examination revealed that no larvae or chrysalides had survived the treatment; 60 days later a third examination corroborated the entire destruction of all living things in the mushrooms, whereas in the reference sample, the insects were thriving at every stage of their life cycle.

It was also found that the mushrooms had in no way been damaged in colour, flavour or bouquet; tests for toxicity made at the Milan University by feeding albino rats for 60 days with mushrooms treated with the maximum quantity of methyl bromide proved that the process is harmless.

The treatment is not costly, representing in Italy about 1/100th of the value of the disinfected mushrooms and has been developed by:—Istituto di Farmacologia e di Terapia dell'Universita degli Studi di Milano, Italy.

Wipe Rabbits off the Map

A new leaflet—"Wipe Rabbits off the Map"—comes as a timely reminder from the Ministry of Agriculture, Fisheries and Food that we are not on top of the rabbit problem yet. Myxomatosis is helping to keep rabbits down and so to a lesser extent are predators, but there can be no doubt that the only reliable way of preventing the return of the rabbit menace, and the vast losses it entails, is by the formation of rabbit clearance societies to get rid of rabbits wherever they appear. This is not a matter that can be left to chance.

That farmers and estate owners are taking a realistic view of the rabbit problem is abundantly clear from the continued growth of rabbit clearance societies. In January, 1959 there were 87 societies covering 4 per cent of the agricultural land and woodland. A year later the number had sprung up to 384 societies, with a 20 per cent coverage. Now there are 633 societies covering 36 per cent. But, encouraging though this is, there is still need for a much greater effort in many parts of the country.

There is a government grant of 50 per cent towards the cost of rabbit clearance. The Government grant also extends to expenditure by rabbit clearance societies on the destruction of wood-pigeon nests and to the cost of cartridges used for shooting wood-pigeons, carrion and hooded crows, rooks, jackdaws and, where they are causing damage, jays and magpies.

The new leaflet draws attention to the legal obligation of occupiers to destroy rabbits on their land and explains the need for group action. It gives details of the Government grants. Copies are available from the Ministry's divisional offices.

Changes in the Poisonous Substances Regulations

Four new chemicals–ethion, mecarbam, phenkapton, and "Thiodan"—have been added to the Regulations for the protection of workers who use poisonous substances in agriculture. This means that farm workers handling these chemicals must now by law observe certain precautions. These include the wearing of protective clothing appropriate to the chemical being used and the operation being performed.

In addition, the stringency of the precautions required when handling the chemical azinphos-methyl (trade name "Gusathion") has been reduced in the light of fresh data which have shown the precautions previously required to be unnecessarily strict.

"Thiodan" becomes a Part II substance; and azinphos-methyl (formerly a Part II substance), ethion, mecarbam and phenkapton become Part III substances under the Agriculture (Poisonous Substances) Regulations 1956/61. This latest amendment—the Agriculture (Poisonous Substances) Amendment Regulations 1961 (S.I. 1961 No. 626)—is obtainable from H.M.S.O. or through any bookseller, price 3d. (by post 5d.).

New Concentrate Sprayer

Micron Sprayers Limited have introduced an interesting addition to their world-famous range of concentrate sprayers. This is the Micron Mantis, a model designed primarily for spraying blackcurrants, hops and cordon fruit.

Fitted with the unique Rotary Atomiser, the Micron Mantis provides excellent atomisation coupled with a high volume of air at low velocity. The wide angle outlet ensures a uniformity of cover.

The machine is remarkably compact, lightweight, and simple in design. It is easy to mount, operate and maintain, and with its 3-point linkage attachment it is suitable for most makes of tractor. The high forward speed permits a rapid rate of application, The low ground pressure and reduced turning circle greatly facilitate manoeuvrability.

P.t.o. driven by Hardy Spicer self-adjusting shaft, the Micron Mantis has a variable drive atomiser, and a belt driven 18 inch fan delivering 8,000 cu. ft. of air per minute. The tank capacity is 20 gallons. Total weight is 2cwts. 19lbs. empty, and the measurements 43 inch $\times$ 32inch $\times$ 20½inch.

A prototype of the Micron Mantis was exhibited at the Smithfield Show.

Export of Plants

Nursery men who are interested in the export of nursery stock, bulbs, seeds, etc., are reminded that before the Ministry of Agriculture, Fisheries and Food can issue the health certificates which certain countries require as a condition of import, one or all of the following requirements may be necessary:-

(1) inspection of consignments immediately prior to export.

(2) crop inspections during the growing season.

(3) soil sampling and testing for Potato Root Eelworm.

An increasing number of countries are now requiring inspection of plants during the growing season in addition to an examination immediately before shipment. Health certificates will not be issued for apple trees, gooseberry and currant bushes, hop sets and cuttings (for most countries) and chrysanthemums (for all countries) unless the stocks have been inspected during active growth.

Soil sampling and testing for Potato Root Eelworm is also required at present before plants can be exported to Algeria, Canada, Czechoslovakia, Denmark, the Federal Republic of Germany, Finland, Hungary, Jamaica, Poland, Sweden, Turkey, U.S.A. and (for certain plants) Northern Ireland and Israel.

The Ministry is prepared to advise growers who anticipate exporting planting material (including plants grown to produce seed for export), and early application for a growing season inspection or for further information should be made to Plant Health Branch, Ministry of Agriculture, Fisheries and Food, Whitehall Place, London, S.W.1.

Research Experts Visit Amani Institute

Two British visitors, Dr. A. B. Hadaway, Officer in Charge of the Colonial Insecticide Research Unit, and Dr. R. L. Muller of the Tropical Products Institute, accompanied by Mr. G. F. Burnett from the Colonial Pesticides Research Unit in Arusha, have visited the East African Institute of Malaria and Vector Borne Diseases at Amani, in Tanga Province, to see the work being carried out in Tanganyika on the biology and control of the snail vectors of human bilharziasis.

The visitors were taken round the Institute by Dr. G. Pringle and Mr. J. N. Raybould, and expressed great interest in the work being done on the chemical control of snails and other pests.

Technical Bulletin and Leaflets

Be your own Lawn Expert. Written by Dr. D. G. Hessayon, Technical Director, Pan Brittanica Industries, Waltham Abbey, Essex and published by the company, this booklet at 1/6d. is a bargain for anyone who has a lawn. An excellent example of how to convey technical know-how and experience to the general reader by the use of simple straight forward language and plenty of diagrams.

1961 *Farmers Guide*. A handbook indicating the agricultural chemicals and services offered to farmers by Crop Protection Limited, Gonerby Hill Foot, Grantham, and obtainable from the company.

Control of the Six-spotted Leaf-hopper in Southern Ontario: This seven page leaflet dealing with the life history, importance and control of *Macrosteles fascifrons*, vector of aster yellows virus. Obtainable from Information Division, Canada Dept. of Agriculture, Ottawa, Ontario, Canada.

National Grassland Demonstration

Following the two National Grassland Demonstrations held in the south of England in 1958 and 1960, the Advisory Committee of the N.G.D. announce that the next demonstration will be held in Yorkshire on Tuesday and Wednesday, June 5th and 6th, 1962. Thanks to the generosity of the Yorkshire Agricultural Society the demonstration will be held on their showground at Harrogate. It is further announced by the sponsors, Shell Chemical Company, that they are hoping to plan for the demonstration to become a permanent feature of the farming calendar and to take place regularly every two years.

By holding the 1962 demonstration in the North of England the Committee hopes that many farmers in the north and in Scotland who missed the two previous demonstrations held in southern England will be able to attend on this occasion.

More Mergers in Rentokil Group

Thomas Harley Ltd. of Perth is the fourth company this year to join Rentokil Group Ltd., Europe's largest organisation in the manufacture and application of pesticides. This 60-year-old public company—"The Piper of Perth"—manufactures the famous Rodine rodenticides, selling throughout the U.K. and in forty-seven overseas countries.

Last June Thomas Harley Ltd., celebrated its Diamond Jubilee. The pharmacist Thomas Harley, founder of the company, first set up his chemist's shop in the city of Perth in 1900. One of his preparations, a rat poison, proved so successful that its manufacture and distribution became his main business. The business expanded, Rodine being sold first to local farmers, then to wholesalers throughout the U.K., and as long ago as 1923 Rodine was being exported to Holland. A four-storey building was erected in Perth, but in 1928 this was superseded by an even larger factory.

This factory is a self-sufficient unit capable of the complete processing of products, tin-moulding and printing, and today Rodine products are sold in 47 countries. It is believed that over the years Rodine has accounted for at least 160 million rats!

Thomas Harley manufacture a rodenticidal paste, Rodine warfarin, and a special Rodine mouse warfarin. Recently, the firm introduced a new 7lb. heat-sealed plastic-lined agricultural pack fitted with a carrying handle for Rodine warfarin.

Another well-known brand line is their moth repellent Modines.

Considerable marketing benefits are to be expected from the inclusion of these products in the range covered by Rentokil Products national coverage.

Another firm, Ridpest Ltd. of 18 Andrew Street, Poplar, London E.14, who specialise in marine pest control, have merged with the marine Division of Disinfestation Ltd. Mr. A. Smith and the Ridpest staff will now be operating as part of this Division.

As a result of the merger, Brian Crust, Manager, Marine Division Disinfestation Ltd., has moved his Head Office, London District Office, Operating Staff and Stores to the former Ridpest offices which are conveniently close to the docks. His telephone number is East 2393.

Disinfestation Ltd. is a member of the Rentokil Group.

Satisfactory Progress with Molluscicides

Surveys in three "pilot" bilharzia control areas in Southern Rhodesia have shown that during the two years of an intensive campaign there has been a great decrease in the incidence of bilharzia. Dr. W. Sheffield, Director of Medical Services for Southern Rhodesia, said on February 3, that he was satisfied with the

results so far obtained and that the experiments would continue. More than 10,000 square miles of the Colony are enveloped by the control programme, which entails the use of molluscicides on a vast scale.

Insect Repellant Curtain

The maintenance of hygienic conditions, particularly in food factories and canteens involves a need to keep out flying insects. This is particularly difficult to achieve whilst maintaining unimpeded entrances at doorways.

A unit to overcome this difficulty has been developed in the form of an "air curtain". blown down by a fan mounted over the open doorway. The curtain issues from a duct made of corrosion proof resin bonded glass fibre, and its direction and velocity are correctly controlled to offer the maximum impedance to penetration by flies, wasps, etc.

The unit is manufactured by Minikay Ltd., 39-41 New Broad Street, London, E.C.2.

Control of Ship Infestations

Speaking on "Pest Control in Shipping" Mr. B. E. Crust, Marine Manager, Disinfestation Ltd., dealt to a large extent with the historical background to the present legislation which provides for the control of pests in ships and gave an account of the main types and sites of rodent and insect infestations found in ships.

In discussing the methods of control used he stated that insecticidal lacquers have proved immensely useful in maintaining ships free of infestation by insects and that extensive trials in recent years have proved that ships can be maintained free from rodents by establishing 'Biotrol' baits throughout the ship.

Biotrol is the name given to an anticoagulant bait which includes a palatable fungicide to prevent the bait becoming mouldy or sour.

Use of absorbent Discs in Cyanide Fumigation.

One of the outstanding pieces of service work carried out during April by the Marine and Fumigation Division of Disinfestation Ltd. was the fumigation of the *Empress of Canada* the newly built flagship of Canadian Pacific Steamships Ltd. Part of the builders contract stipulated that the entire ship was to be fumigated prior to being handed over to the Owners in order to obtain a valid International Deratization Certificate.

All accomodation and catering sections, storerooms, cargo spaces, engine and boiler rooms, generator room etc. had to be treated and one can imagine the care and detail required to ensure that a vessel of this type had been completely vacated and properly sealed to ensure that she was "gas-tight" prior to the introduction of the fumigant, and to introduce the fumigant in such a manner to ensure that no damage was caused to the luxurious fittings, furnishings, rubber deckings, etc. Hence the decision to use absorbed cyanide—applied by a patented discoid system—rather than liquid cyanide.

The cyanide was distributed in small absorbent discs which give a complete coverage with the correct concentration of gas in every space. The removal of the discs after the period of exposure ensured the early clearance of the gas, and avoided delay in handing the ship to the owners.

She was handed over to Disinfestation operating staff at 12-30 on Easter Saturday and was completely under fumigation at 13-00 hours. The ventilation of the vessel was begun at 17-00 hours on that day and she was returned to her owners at 07-30 hours on Easter Sunday, after thorough testing throughout to ensure that she was "gas-free" and fit for rehabitation, which, one will appreciate, was no mean task.

She will now be regularly serviced by Disinfestation Ltd., to maintain an insect-free condition and will probably be fumigated annually in a similar manner to the remainder of the C.P.S. fleet.

Notes from a conference

Every two years the Rentokil Group holds a Pest Control Conference for the benefit of its employees. The benefits are two fold, first it enables members of the organization to become aquainted with the other members and their work—a most important consideration for this large organization whose employees are distributed throughout the length and breadth of Great Britain and, in some cases, overseas. Secondly, the papers presented at the Conference allow the members to keep up to date with advances in pest control research and practice.

This year's conference was held at the Grand Hotel, Brighton, and papers were read throughout Friday 29th April and Saturday morning. A great deal of information was packed into the 1½ days because the organisers had preprinted the main papers so that in their talks the authors only needed to give a brief outline account, emphasise the main points, or give a running commentary on lantern slides or films

Mr. P. L. Burgin, Chairman of the Rentokil Group Ltd., opened the proceedings with an account of "The Development of the Group" which was followed by a most intriguing paper on "The Growing Menace of Woodworm" given by A. A. Tyrer, General Manager, Woodworm and Dry Rot Control Ltd.

According to Mr. Tyrer, the economic importance of woodworm was illustrated by the fact that from 10,420 property surveys carried out in 1959 by Woodworm & Dry Rot Control Ltd. the incidence of infestation by *Anobium punctatum* (the House Borer or Furniture Beetle) was 82.93%. Whilst it is obvious that this percentage infestation for 10,420 properties cannot be directly related to the total number of houses in Great Britain (thirteen and a half million) it does suggest that the country is faced with a serious infestation problem which is increasing in intensity. The reasons for this were discussed by Mr. Tyrer against the historical background of timber usage, population increase and social conditions.

Only after the 14th century was attention given to the building of dwelling houses for the general community, but from this time to the 17th century the country was engaged in an almost continuous building programme aimed at housing the ever increasing population. However, craftsman practice was such that mature hardwood timbers (usually oak) free of sapwood, were utilized and this alone indicates a low level of susceptibility to *Anobium* infestation, a level further depressed by limited communications between widely scattered settlements with the attendant low risk of spread of infestation.

The industrial revolution in the 18th & 19th centuries served to improve communications by road, river and rail thus increasing the risk of spreading *Anobium* infestation. Moreover by this time the indigenous stocks of hardwood had become

virtually exhausted and the more susceptible softwoods were being used in grand scale building programmes to house the dynamically expanding population (from 1851-1911 the population increased from approx. 18 to 36 million) thus again further increasing the risk of *Anobium* infestation. The risk, however, was contained within reasonable bounds due to the high standards of professional and craftsman practice which prohibited the use of significant amounts of sapwood.

Following the first world war the cost of timber spiralled due to the depletion of stocks during the war, the increase in population, and the need to rehouse the population from the insanitary slum towns built during the industrial revolution. Indeed from 1921-39 some 4,300,000 houses were built, many of which were erected by the speculative builder, others being council houses. It had become impossible to obtain any quantity of structural timber which did not contain significant amounts of sapwood.

The result was a rapid acceleration in the already established susceptibility to *Anobium* infestation in structural softwood timbers—a susceptibility which was revealed in the immediate post World War II years. In the years following the second world war the pattern of supply and demand for structural timber repeated that which followed the first world war except that the demand was greater and the supply less; thus the amount of low grade *Anobium* susceptible timber increased. Yet another factor had to be considered, the sapwood containing timbers used in the 1920's had in the war years reached the stage of maturity where the risk of *Anobium* attack was greatest but because of the demands of war little attention could be paid to the problem and infestations were allowed to become established. Moreover, in addition to the trend to increasing sapwood content there had been also a trend towards a reduction in the dimensions of structural timbers. On both counts the risk of structural failure as a consequence of decay by insects is greater.

Mr. Tyrer concluded his paper by briefly stating methods by which the menace of woodworm could be avoided in the future and how the present situation could be remedied.

"Extensive trials and practical commercial applications have been carried out over the past nine to ten months, all of which have proved 100% successful. On every building or part of a building on which Scarecrow Strip has been applied, the infestations of pigeons and starlings have been cleared, and the treated structures have since remained clear. The birds have left the treated area severely alone."

Mr. R. K. Farmer, Laboratory Controller, Rentokil Research Laboratories, who emphasised the need for standard methods in his paper "Techniques Used in Evaluating Pesticides" was also largely responsible for the production of an excellent colour film on cockroaches ("The Intruders") which was used by the next speaker, Mr. R. E. Welch, Regional Manager, Disinfestation Ltd., to illustrate his paper on "Cockroach Control". This latter paper showed that although the morphology of the cockroach has changed little in the past fifty million years its habits and adaptability make it a most difficult pest to control.

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